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Dwarf Mistletoe of Ponderosa Pine in the Southwest

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Southwestern dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum*) occurs essentially throughout the range of ponderosa pine (*Pinus ponderosa* var. *scopulorum*) from northern Mexico through western Texas, Arizona, and New Mexico into Colorado and central Utah. In Arizona and New Mexico it is present on more than one-third of the commercial forest acreage and is estimated to cause losses, due to growth reduction and mortality, of over 150 million board feet annually. Although the principal and most valuable tree species attacked is ponderosa pine, this dwarf mistletoe also commonly parasitizes Apache (*P. engelmannii*) and Arizona (*P. ponderosa* var. *arizonica*) pines. Lodgepole pine (*P. contorta*) is an occasional host, limber (*P. flexilis*), bristlecone (*P. aristata*), and southwestern white (*P. strobiformis*) pines are very rare hosts.

Life History

The aerial system of this parasitic seed-bearing plant consists of leafless, yellow to green or brownish-green segmented perennial shoots that average 4 to 6 inches long and one-eighth to one-quarter inch in diameter (fig. 1A). Shoots may reach 10 inches or more in length, and a half-inch basal diameter. Although the shoots contain some chlorophyll and manufacture some of their own food, the parasite gets most of its nutrients through its endophytic system, a specialized rootlike system, from living tissues of its host. "Roots" consist of cortical strands that grow through the phloem and bark tissues, and secondary rootlike structures (sinkers) that become imbedded in the wood as the twig adds its annual rings.

Male and female flowers are produced on separate plants. Small, inconspicuous flowers (fig. 1B) arise from axils of shoot segments in May or June. Female flowers are pollinated by insects and fruits (fig. 1C) develop during the next 14 to 15 months, ripening in late summer. Mature fruits are ovoid berries about three-sixteenths inch long. Their color is similar to that of the shoot, but the upper and lower parts of the fruit are of different shades of green.

Seeds are generally dispersed in late July and early August. Explosive discharge, by buildup of internal water pressure within the fruit, causes the seed to be propelled at an initial velocity of about 85 feet per second (60

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Figure 1.—Features of the dwarf mistletoe plant: *A*, cluster of female shoots that have developed from a single infection; *B*, part of a shoot bearing male flowers in bloom; *C*, part of a shoot bearing nearly mature fruits or berries; *D*, germinated seed showing radicle penetrating bark at the base of needle bundle sheath.

miles per hour). Maximum horizontal distance of seed flight is 40 to 50 feet, but most seeds alight within 15 feet of the source plant. Seeds (fig. 1D) are small (about one-eighth inch long), tear shaped, and usually olive green, becoming reddish brown when dried. They are sticky and will adhere to most objects they strike. In one stand studied, about 40 percent of the discharged seeds were intercepted by surrounding trees. Over 90 percent of the in-

tercepted seeds landed on needles, the rest on the twigs or bole. Seeds remain on the needles until the first rain. When their mucilaginous coating absorbs moisture, they become slippery, slide down to the branch at the base of the needle fascicle, and stick to the bark.

Seeds germinate within a month after dispersal. Seeds of all other dwarf mistletoes in the United States germinate in the spring after overwintering on the hosts. The radicle (root) grows along the surface of the host until it encounters an obstacle, or its food supply is exhausted. Upon encountering an obstacle, such as the base of a bud or needle bundle sheath (fig. 1D), the radicle forms a mound of tissue that acts as a holdfast from which the primary rootlike organ penetrates living susceptible host bark. Out of this primary organ grow threadlike strands that develop into the specialized root system, called the endophytic system.

Infection is established within a few months after seed dispersal. Most infection occurs through the bark on the needle-bearing portion of twigs, but infection may occur through bark as old as 9 years. Once living tissues of the host are reached, the parasite no longer depends on its own nutrient supply. The enlarging endophytic system develops subsequently within the host branch. About 2 to 5 years elapse between infection and appearance of the first aerial shoots. The minimum time needed for a female plant to complete its life cycle (seed dispersal to a new seed-bearing plant) is 4 years, but usually 6 or more years are required.

Spread and Intensification

Southwestern dwarf mistletoe spreads slowly through stands of ponderosa pine, averaging about 1.7 feet a year in open young stands and about 1.2 feet a year in dense young stands. When evaluated by the 6-class rating system (Hawksworth 1961, p. 77), the infection class of individual trees will usually progress to the next more severe class in about 10 to 12 years due to the combined effects of intensification within the tree and infection from adjacent trees.

Explosive discharge of seeds is responsible for nearly all spread. Birds presumably are involved in long-distance transport of seeds. Squirrels and porcupines may also be responsible for establishment of new infections separated by short distances from established centers. Wind is unimportant in dissemination of dwarf mistletoe in the Southwest.

Symptoms and Signs of Infection

Witches' brooms.—The first visible symptom is a slight swelling of the bark at the sight of infection. As time passes and the endophytic system of the parasite becomes more extensive, the branch habit of the host becomes distorted and witches' brooms may be formed (fig. 2). Broomed branches usually outlive their uninfected neighbors by many years. They divert food from uninfected parts of the tree and thus are instrumental in reducing vigor and causing premature death of the host. Long-lived witches' brooms also result in excessively large knots; it is not uncommon for the bases of broomed branches on otherwise clear trunks to reach 12 inches in diameter.

Trees may be seriously infected without developing typical witches' brooms, but mistletoe shoots will usually be abundant and widespread along the live branches throughout the crown.

Decline and Mortality.—Seedlings and saplings often die suddenly. Older trees, however, undergo a period during which foli-

Figure 2.—Deformities of ponderosa pine caused by dwarf mistletoe: *A*, single witches' broom confined to a living limb; *B*, witches' brooms scattered throughout the thin crown of short yellowish needles in a tree whose top has died as a result of heavy dwarf mistletoe infection; *C*, witches' brooms in a tree killed by dwarf mistletoe.

age gradually becomes thin, short, and yellowish, and the top dies (fig. 2B). The entire tree dies after a variable period of reduced growth, either as a direct result of parasitism or from attack by secondary pests.

Damage

Lightly infested stands suffer little from this parasite, and cannot readily be distinguished from healthy stands. The effects of dwarf mistletoe are progressive, however, and lightly infested stands become moderate and then heavily infested, resulting in gradual stand deterioration and giving the impression of poor site conditions. Heavily infested stands contain deformed, stunted, dying, and dead trees. Dead older trees show the unmistakable branch habit of old witches' brooms (fig. 2C), and there is always some branch malformation, even on dead young trees.

Heavily infected trees grow more slowly than uninfected trees. The effect of the parasite is most pronounced on recent radial increment and total volume, intermediate on height growth, and least on total diameter. In multiaged stands, dwarf mistletoe-caused mortality and growth losses offset average increment per tree in both moderate and heavy infection classes. In pole stands, combined losses offset average increment per tree only in heavy infection classes. Because of the combined effects of growth loss and mortality, yields are substantially reduced. For example, a stand on a site with an index of

70 infested by age 10 will produce less than 7,000 board feet of merchantable volume per acre at age 130. Uninfested stands on comparable sites can be expected to produce more than three times as much volume. The effects of dwarf mistletoe are even more pronounced on poor sites.

Seedlings and saplings, especially those with main stem infections, readily succumb to the parasite. Those weakened by numerous branch infections cannot compete successfully with surrounding trees, and are eventually crowded out. Infected mature and overmature trees may die from the debilitating effects of the parasite or from attacks of secondary pests. In either case, considerable volume is lost.

Wood quality of infected trees may be reduced by large knots, the pitchy, distorted grain, and lowered strength of the infected wood. Infected trees are utilized for pulp, but the reduction in pulp yield and fiber quality is unknown.

Trees moderately or heavily infected with dwarf mistletoe produce fewer cones, fewer good seeds per cone, and thus less seeds per tree, than uninfected trees. There is little, if any, effect on the number of seeds per pound, but seeds produced on infected trees germinate poorly compared to seeds produced on uninfected trees. The product of these three factors (yield per tree in pounds of clean seed x number of clean seeds per pound x final germination percent), called "reproductive value", represents a summation of the fundamental variables of seed production. Increasing infection levels cause a decrease in reproductive values so that moderately infected trees have values about 60 percent less, and heavily infected trees about 75 percent less, than healthy trees. Most heavily infected trees do not produce cones.

Control

The only control measures now available for reducing or eliminating southwestern dwarf mistletoe populations are silvicultural. Many chemicals have been investigated as control agents but none has been found that kills the parasite without undue damage to the host. Similarly, no promising biological control agents have yet been detected. Apparently resistant trees are occasionally found, but the nature and inheritability of resistance have received little attention.

Sanitation is the best means of achieving silvicultural control. It consists of killing heavily infected trees and pruning lightly infected ones. Sanitation measures to be applied to commercial stands differ somewhat from those for recreational forests, although protection of developing reproduction is the primary long-range goal in both. Treatment of commercial stands relies heavily on removing infected trees, whereas treatment of recreation stands emphasizes pruning infected branches.

Control in Commercial Forests.—In forests under even-aged management, the most desirable time to sanitize is during the regeneration period. In heavily infested stands, clearcutting may be the best solution. In this case all merchantable trees should be harvested, and all of the remaining trees destroyed. If regeneration is to be accomplished by seed tree or shelterwood methods, the seed trees should be preselected. Because the reproductive value of moderately and heavily infected trees is greatly reduced, only uninfected or lightly infected seed trees should be chosen. Infected seed trees should be harvested within 10 years after reproduc-

tion is established to protect the new crop of trees from infection.

Dwarf mistletoe control is difficult in forest stands under all-age management. Not all infected trees can be removed before the younger trees become infected, and the disease is therefore perpetuated. To keep infection levels to a minimum, sanitation should be thorough in both the overstory and understory. Overstory treatment should be suspended during the mistletoe seed dispersal period, mid-July to mid-August, to protect the young trees from seeds dispersed by logging activities. High costs limit the use of pruning to understory trees, but it is sometimes carried out in conjunction with thinning to remove infected branches from particularly desirable trees. Guides for pruning are discussed in the section, Hints on Pruning.

Because new dwarf mistletoe infections undergo a 3- to 5-year latent period before producing aerial shoots, not all infection can be detected and removed during initial control operations. At least one treatment will be needed, 5 to 10 years after the initial treatment, to reduce the level of infection. Additional treatments may be needed at 5- to 10-year intervals to keep infection levels low. In most cases, they can be accomplished during regularly scheduled silvicultural treatments.

Control in Recreational Forests.—Sanitation is often required to prolong the life of high-value trees in campgrounds, administrative sites, recreation stands, and similar areas. In these locations pruning of infected branches is emphasized. Control must still begin, however, with treatment of the overstory.

Sanitation should begin by removing trees with more than half their branches infected or with their upper crowns heavily infected. Trunk infections, located where the stem is larger than 8 inches in diameter, usually contribute little to spread and do little or no harm to the tree. Such trees need not be removed. Trunk infections where the stem is less than 8 inches in diameter can be major contributors to spread of the parasite, and, in small trees, frequently lead to early mortality. These trees should be removed.

In general, pruning should be limited to lightly infected trees (infection classes 1 or 2). The number and extent of sanitation treatments necessary is directly related to the proportion of trees pruned initially. If heavy pruning is necessary in the initial sanitation of an area, many subsequent treatments will be required, because most pruned trees have to be repruned several times in order to remove the latent infections that develop. One study showed that successful elimination of dwarf mistletoe from a tree is strongly correlated with amount of infection in the tree at the time of the initial pruning:

Original dwarf mistletoe rating	*Proportion of trees alive 20 years later*
1	70
2	50
3	40
4	10

Pruning should also be confined, as far as possible, to the more isolated trees. Pruning residual trees in once heavily infected groups of pole-sized trees is generally unsuccessful. In such situations many of the residual trees will become so heavily infected from developing latent infections that they will have to be killed.

Hints on Pruning.—In pruning, the infected branch should be cut off at the bole. Although it may at first appear easier to remove infected secondary or tertiary branches, the high incidence of latent dwarf mistletoe in the remaining branches makes this

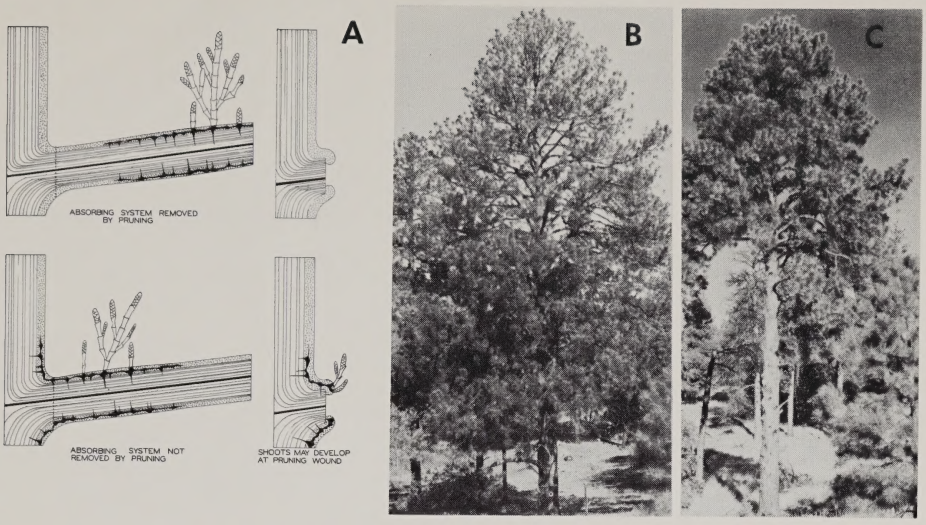

Figure 3.—The results of pruning dwarf mistletoe-infected branches: *A*, diagrammatic representation of dwarf mistletoe plants at different distances (consult table) from the trunk, showing why pruning is sometimes ineffective as a sanitation measure; *B*, a ponderosa pine tree with heavy brooms in the lower crown and a thin upper crown of short needles; *C*, the same tree approximately 11 years after the brooms were pruned out. Note the greatly increased vigor.

practice questionable. In most cases the entire branch will have to be removed in subsequent prunings.

If large portions of the crown are removed by pruning, isolated living branches should not be left. Even though dwarf mistletoe may not be apparent in such branches, they almost invariably harbor latent infections. Where it is possible to do so without removing too many branches, pruning for two or three whorls above the highest visible mistletoe will eliminate many latent infections and thus save a considerable amount of time in subsequent sanitations.

The extent of the endophytic system of branch infections and success in pruning is related to branch diameter (fig. 3A). The extent of the endophytic (or root) system of ponderosa pine dwarf mistletoe, and thus success in pruning, is known to be as follows:

Branch diameter at bole (inches)	*Minimum safe distance from bole to closest shoots* (inches)
under 1	6
1 to 2	8
2 to 3	10
3 to 4	12

Pruning heavily infected trees improves their vigor. Heavily infected trees of infection class 4 or 5, so severely infected that the tops of the crowns are thin and off color, can recover even though dwarf mistletoe is not necessarily eliminated from them (fig. 3B, 3C). Removing the lower infected branches which are seriously reducing the vitality of the tree can prolong the life of the tree considerably. While such drastic pruning is not recommended as a routine control measure, it can be used to lengthen the life of particularly valuable or needed trees.

Dwarf mistletoe shoots die as soon as the tree or branch is cut, so burning or destroying the

shoots is unnecessary. Trees and large branches removed during sanitation should not be piled near living trees because they provide ideal breeding material for destructive insects.

References

DWARFMISTLETOE CONTROL IN SOUTHWESTERN PONDEROSA PINE FORESTS UNDER MANAGEMENT. Lake S. Gill and Frank G. Hawksworth. J. For. 52: 347-353. 1954.

DWARFMISTLETOE OF PONDEROSA PINE IN THE SOUTHWEST. Frank G. Hawksworth. U.S. Dep. Agric. Tech. Bull. 1246, 112 p. 1961.

YOU CAN SAVE YOUR PINES FROM DWARFMISTLETOE. Frank G. Hawksworth, James L. Stewart, and Wilmer F. Bailey. USDA For. Serv. Res. Pap. RM-35, 21 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 1968.

CONTROL OF DWARF MISTLETOE IN A HEAVILY USED PONDEROSA PINE RECREATION FOREST: GRAND CANYON, ARIZONA. Paul C. Lightle and Frank G. Hawksworth. USDA For. Serv. Res. Pap. RM-106, 22 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 1973.

THE WESTERN YELLOW PINE MISTLETOE. Clarence F. Korstian and W. H. Long. U.S. Dep. Agric. Bull. 1112, 35 p. 1922.

SIMULATING YIELDS OF SOUTHWESTERN PONDEROSA PINE STANDS, INCLUDING EFFECTS OF DWARF MISTLETOE. Clifford A. Myers, Frank G. Hawksworth, and Paul C. Lightle. USDA For. Serv. Res. Pap. RM-87, 16 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo. 1972.

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